What is claimed is:

1. A Raman amplifier for supplying pumping lights to an amplification medium through which is propagated a wavelength division multiplexed signal light obtained by multiplexing a plurality of signal lights of different wavelengths, to amplify the wavelength division multiplexed signal light due to a Raman effect, comprising:

a first pumping light generating section that generates a plurality of pumping lights arranged at equal wavelength spacing in a signal light wavelength band where said plurality of signal lights are arranged, which is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to a Raman shift frequency;

a second pumping light generating section that generates pumping lights of one or more wavelengths arranged in a wavelength band on at least one of a shorter wavelength side and a longer wavelength side than a wavelength band of the pumping lights generated by said first pumping light generating section, the wavelength and power of which are set so that peak wavelength spacing of a Raman gain in the signal light wavelength band is substantially equal to each other; and

a multiplexing section that multiplexes the pumping lights generated respectively by said first and second pumping light generating sections to supply the multiplexed pumping light to said amplification medium.

2. A Raman amplifier according to claim 1, further comprising;

a gain equalizer having the periodicity corresponding to the peak wavelength spacing of the Raman gain in the signal light wavelength band, to reduce the wavelength deviation of the power of the Raman amplified wavelength division multiplexed signal light.

3. A Raman amplifier according to claim 1, further comprising:

a monitoring section that monitors a wavelength characteristic of the power of the wavelength division multiplexed signal light that has been propagated through said amplification medium and has been Raman amplified; and

a control section that controls at least of one of the wavelength and power of the pumping light generated by said second pumping light generating section according to a change in a wavelength characteristic of the Raman gain in the signal light wavelength band, judged based on the monitoring result of said monitoring

section.

4. A Raman amplifier according to claim 1,

wherein the wavelength allocation is adopted, in which the signal light wavelength band is narrower than a wavelength band corresponding to the Raman shift frequency, and a signal light wavelength band and a pumping light wavelength band are separated from each other.

5. A Raman amplifier according to claim 1,

wherein the wavelength allocation is adopted, in which the signal light wavelength band has a wavelength width substantially corresponding to the Raman shift frequency or more, and the pumping lights are mixed into the signal light wavelength band.

6. A Raman amplifier according to claim 5, further comprising;

an optical filter rejecting a Rayleigh scattered light of each pumping light mixed in the signal light wavelength band.

7. A Raman amplifier according to claim 5, further comprising;

an optical filter having the periodicity corresponding to peak wavelength spacing of the Raman gain in the signal light wavelength band, to reduce the wavelength deviation of the Raman gain and, at the same time, to reject a Rayleigh scattered light of each pumping light mixed in the signal light wavelength band.

8. A Raman amplifier according to claim 5, further comprising;

an optical filter having the periodicity corresponding to peak wavelength spacing of the Raman gain in the signal light wavelength band, to reduce the wavelength deviation of the Raman gain and, at the same time, to narrow the spectrum of each pumping light.

9. An optical transmission system comprising a Raman amplifier in claim 1.

10. An optical transmission system according to claim 9,

wherein said Raman amplifier is provided in each of a plurality of optical repeater stations disposed on an optical transmission path connecting between optical terminal stations.

11. An optical transmission system according to claim 10, further comprising;

a gain equalizer compensating for the gain deviation of the Raman gain that has not been equalized to remain in each repeater section, for each of a plurality of repeating sections.

12. A Raman amplifier for supplying pumping lights to an amplification medium through which is propagated a wavelength division multiplexed signal light obtained by multiplexing a plurality of signal lights of different wavelengths arranged in a wavelength band corresponding to about two times or more a Raman shift frequency, to amplify the wavelength division multiplexed signal light due to a Raman effect, comprising:

a pumping light source generating a plurality of pumping lights arranged in a signal light wavelength band where said plurality of signal lights are arranged, which is shifted to a shorter wavelength side in accordance with a wavelength width corresponding to the Raman shift frequency;

a pumping light power control section that controls the power of the pumping lights generated by said pumping light source so that either minimal values or maximal values of a wavelength characteristic of a Raman gain in the signal light wavelength band are substantially the same;

an optical circulator supplying the pumping lights generated by said pumping light source to said amplification medium;

a demultiplexer demultiplexing the wavelength division multiplexed signal light that has been propagated through the amplification medium and has been Raman amplified, into a plurality of wavelength bands previously set according to the wavelength deviation of the Raman gain;

a plurality of gain equalizers reducing the wavelength deviation of the power of the wavelength division multiplexed signal light demultiplexed by said demultiplexer, for each of the wavelength bands; and

a multiplexer multiplexing the signal light output from each of said gain equalizers.

13. A Raman amplifier according to claim 12,

wherein said plurality of wavelength bands are set so that a range where the wavelength deviation of the Raman gain is substantially the same is made one wavelength band.

14. A Raman amplifier according to claim 12,

wherein said pumping light source includes:

a first pumping light generating section that generates a plurality of pumping light arranged at equal wavelength spacing in the signal light wavelength band, which is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to the Raman shift frequency.

a second pumping light generating section that generates pumping lights of one or more wavelengths arranged in a wavelength band on at least one of a shorter wavelength side and a longer wavelength side than a wavelength band of the pumping lights generated by said first pumping light generating section, the wavelength and power of which are set so that peak wavelength spacing of the Raman gain in the signal light wavelength band are substantially equal to each other; and

a multiplexing section that multiplexes the pumping lights generated respectively by said first and second pumping light generating sections to send the multiplexed pumping light to said optical circulator.

15. A Raman amplifier according to claim 12, further comprising;

an optical filter rejecting a Rayleigh scattered light of each pumping light mixed in the signal light wavelength band.

16. A Raman amplifier according to claim 15,

wherein a center wavelength of a guard band of said demultiplexer set at a boundary between said plurality of wavelength bands coincides with a loss peak wavelength of said optical filter set corresponding to a center wavelength of each pumping light.

17. An optical transmission system comprising a Raman amplifier in claim 12.

18. An optical transmission system according to claim 17,

wherein said Raman amplifier is provided in each of a plurality of optical repeater stations disposed on an optical transmission path connecting between optical terminal stations.

19. An optical transmission system according to claim 18, further comprising;

a gain equalizer compensating for the gain deviation of the Raman gain that has not been equalized to remain in each repeater section, for each of a plurality of repeating sections.

20. A Raman amplifier for supplying pumping lights to an amplification medium through which is propagated a wavelength division multiplexed signal light obtained by multiplexing a plurality of signal lights of different wavelengths arranged in a wavelength band corresponding to a Raman shift frequency or more, to amplify the wavelength division multiplexed signal light due to a Raman effect, comprising:

a pumping light source generating a plurality of pumping lights arranged in a signal light wavelength band where said plurality of signal lights are arranged, which is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to the Raman shift frequency;

a pumping light power control section that controls the power of the pumping lights generated by said pumping light source so that minimal points and maximal points of a wavelength characteristic of a Raman gain in the signal light wavelength band are placed substantially in uniformity, in a positive region and a negative region with a previously set reference gain value as a boundary;

an optical circulator supplying the pumping lights generated by said pumping light source to said amplification medium; and

a gain equalizer reducing the wavelength deviation of the power of the wavelength division multiplexed signal light over the entire signal light wavelength band.

21. A Raman amplifier according to claim 20,

wherein said pumping light source includes:

a first pumping light generating section that generates a plurality of pumping light arranged at equal wavelength spacing in the signal light wavelength band, which is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to the Raman shift frequency.

a second pumping light generating section that generates pumping lights of one or more wavelengths arranged in a wavelength band on at least one of a shorter wavelength side and a longer wavelength side than a wavelength band of the pumping lights generated by said first pumping light generating section, the wavelength and power of which are set so that peak wavelength spacing of the Raman gain in the signal light wavelength band are substantially equal to each

other; and

a multiplexing section that multiplexes the pumping lights generated respectively by said first and second pumping light generating sections to send the multiplexed pumping light to said optical circulator.

22. A Raman amplifier according to claim 20, further comprising;

an optical filter rejecting a Rayleigh scattered light of each pumping light mixed in the signal light wavelength band.

23. A Raman amplifier according to claim 20, further comprising;

an optical filter having the periodicity corresponding to peak wavelength spacing of the Raman gain in the signal light wavelength band, to reduce the wavelength deviation of the Raman gain and, at the same time, to reject a Rayleigh scattered light of each pumping light mixed in the signal light wavelength band.

24. A Raman amplifier according to claim 20, further comprising;

an optical filter having the periodicity corresponding to peak wavelength spacing of the Raman gain in the signal light wavelength band, to reduce the wavelength deviation of the Raman gain and, at the same time, to narrow the spectrum of each pumping light.

25. An optical transmission system comprising a Raman amplifier in claim 20.

26. An optical transmission system according to claim 25,

wherein said Raman amplifier is provided in each of a plurality of optical repeater stations disposed on an optical transmission path connecting between optical terminal stations.

27. An optical transmission system according to claim 26, further comprising;
a gain equalizer compensating for the gain deviation of the Raman gain that has not been equalized to remain in each repeater section, for each of a plurality of repeating sections.

28. A Raman amplifier for supplying pumping lights to an amplification medium through which is propagated a wavelength division multiplexed signal light obtained by multiplexing a plurality of signal lights of different wavelengths arranged in a

wavelength band corresponding to approximately two times a Raman shift frequency or more, to amplify the wavelength division multiplexed signal light due to a Raman effect, comprising:

a pumping light source generating a plurality of pumping lights arranged in a signal light wavelength band where said plurality of signal lights are arranged, which is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to the Raman shift frequency; and

an optical circulator supplying the pumping lights generated by said pumping light source to said amplification medium,

wherein the pumping light wavelength, which is shorter by even number times the wavelength width corresponding to the Raman shift frequency than the longest pumping light wavelength among said plurality of pumping light wavelengths, is not coincident with a wavelength of about 1.4μm (about 214THz in frequency), which is a wavelength of OH-absorption loss possessed by an optical fiber.

29. A Raman amplifier according to claim 28,

wherein, in two pumping light wavelengths, a wavelength deviation between which corresponds to the Raman shift frequency, the power of each of the pumping lights is modulated to reduce a correlation between each pumping light.

30. A Raman amplifier according to claim 28,

wherein among the pumping light wavelengths, which are shorter by even number times the wavelength width corresponding to the Raman shift frequency than said longest pumping light wavelength, the pumping light wavelength closest to said OH-absorption loss is allocated in a wavelength range apart by 1/3 to 3/3 times the wavelength width corresponding to the Raman shift frequency from said wavelength of OH-absorption loss .

31 A Raman amplifier for supplying pumping lights to an amplification medium through which is propagated a wavelength division multiplexed signal light obtained by multiplexing a plurality of signal lights of different wavelengths arranged in a wavelength band corresponding to approximately two times a Raman shift frequency or more, to amplify the wavelength division multiplexed signal light due to a Raman effect, comprising:

a pumping light source generating a plurality of pumping lights arranged in a signal light wavelength band where said plurality of signal lights are arranged, which

is shifted to a shorter wavelength side in accordance with the wavelength width corresponding to the Raman shift frequency; and

an optical circulator supplying the pumping lights generated by said pumping light source to said amplification medium,

wherein a pumping light wavelength is not allocated in the vicinity of a wavelength, which is shorter by even number times the wavelength width corresponding to the Raman shift frequency than the longest pumping light wavelength among said plurality of pumping light wavelengths, to have an invalid signal wavelength band exist in the vicinity of a wavelength, which is shorter by odd number times the wavelength width corresponding to the Raman shift frequency than said longest pumping light wavelength.

32. A Raman amplifier according to claim 31,

wherein, in two pumping light wavelengths, a wavelength deviation between which corresponds to the Raman shift frequency, the power of each of the pumping lights is modulated to reduce a correlation between each pumping light.

33. A Raman amplifier according to claim 31 ,

wherein a wavelength band in which the pumping light is not arranged to have said invalid signal wavelength band exist, is a wavelength range, which is apart by 1/3 times the wavelength width corresponding to the Raman shift frequency to a shorter wavelength side and a longer wavelength side from the wavelength, which is shorter by even number times the wavelength width corresponding to the Raman shift frequency than said longest pumping light wavelength.

34. A Raman amplifier according to claim 31 , further comprising:

a demultiplexer demultiplexing the wavelength division multiplexed signal light that has been propagated through said amplification medium to be Raman amplified, into a plurality of wavelength bands previously set according to a guard band generated as a result that the pumping light wavelength is not allocated;

a plurality of gain equalizers reducing a wavelength deviation of the power of the wavelength division multiplexed signal light demultiplexed for each wavelength band by said demultiplexer; and

a multiplexer multiplexing the wavelength division multiplexed signal light output from said each gain equalizer.